

PEER REVIEW AND QUALITY ASSURANCE
OF DETERMINISTIC SAFETY ANALYSIS FOR LENINGRAD NPP UNIT 2

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ABSTRACT

Two task were delivered before the authors of the production reports (the Designer), which carried out the Deterministic Safety Analysis (DSA) for Leningrad NPP Unit 2 . In conformity with the first task it was needed to receive the material, sufficient for reception of the licence for further operation of this power unit. In this case it was necessary to prove, that all the design-basis accidents will not lead to the failure of acceptance criteria, i.e. in the first turn there will not be the failures of the fuel cladding. If to use the modern concepts, that means that the size of the risk for all the design-basis accidents is equal to zero. The second task of the executed work was consisted in giving help for so called Deterministic Support to the Probabilistic Safety Analysis (PSA). It means, that the Designer should analyse only such emergency sequences, which cause the damage of fuel elements. In this case the Designer should, firstly, to determine the category of fuel element damage for emergency sequence considered and, secondly, to dermine its probability or frequency. It is easily to see, that objectives of these two tasks are opposite, one task excludes the other. In one task it needs to prove, that there are no fuel elements damage. In the second task it is necessary to prove the opposite result, there is damage of fuel elements, though the possibility of these is very small. Within frame of the Deterministic Safety Analysis the researchers of production reports the second task was not decided. The Designer carried out the work in conformity with the rules of the classical Deterministic Safety Analysis. Therefore the results of their work may be tried to apply only for reception of licensing for further operation of power unit. The work reviewed was consisted of the next three in essence various parts: 1. Choice of Enitiating Event, 2. Choice of Single Failure, 3. Calculations with the help of RELAP code.

CALCULATIONS with HELP of RELAP CODE

This part includes: preparation of the nodalization scheme of the power unit, preparation of geometrical and thermo-hydraulic parameters of the power unit, execution of the calculations. NODALIZATION SCHEME. The first nodalization scheme of the RBMK reactor was developed in RRC "Kurchatov Institute" more than 10 years ago. The one described only the Circulation Circuit. Further the scheme was transferred to th Designer . During past time the Designer developed a huge work in this direction:

1. has improved the description of the thermo-hydraulic of the reactor core,
2. for each Initiating Event has prepared appropriate nodalization scheme,
3. has described in details the feed water path and Emergency Core Cooling System (ECCS),

4. has described in details the system of Main Steam Lines and the System of Steam Relief. It is possible to say, that at the present time the Designer has the most developed nodalization scheme of the thermo-hydraulic circuit of the power unit with the RBMK reactor. INITIAL DATA. Geometrical parameters of the circulation circuit were made more exact during the last 10 years. Evidently in this place the Designer also reached perfection, in particular, good concurrence of results with the experiment data for the stationary condition speaks about it. FULFILMENT of CALCULATIONS. The Designer has the modern computer facilities. If before transients analysed were some minutes of duration, but now the duration of these analysed processes is about some hours.

INITIATING EVENTS

In the production reports only main, in the Designer's opinion, Initiating Events are considered. Certainly, these Initiating Events are unsufficiently for the reception of the licence for further

operation of the power unit. But, in accordance with the Designer's statement, the quantity of Initiating Events considered were restricted by the terms and by the volume of financing.

Nevertheless the choice of the Initiating Events was conducted not always correctly.

EXAMPLE 1. Here breakage of two Main Steam lines was analysed. In the presence of it it was accepted, that at the moment of beginning of failure the Main Circulation Pumps (MCPs) were disconnected. With such circumstances this researchers speak that the consideration of this failure causes the conservative result. In our opinion the statement is disputable. In case of breakage of only one Main Steam Line the flow rate of the coolant through the reactor core will be less and, hence, the temperature of fuel elements will be higher. For the right answer on this question it is necessary to execute the appropriate calculations with help of RELAP code.

EXAMPLE 2. Here a false operation and failure to close of four Main Steam Relief Valves (MSRVs) is considered. The Initiating Events of the Examples 1 and 2 for character of occurring processes are close between among themselves. And here and there the large steam relief from the circulation circuit occurs. Therefore the calculation scheme should be close also among themselves. However the authors of the production reports act otherwise. In Example 1 at the instant of the failure switching-off of the Main Circulation Pumps (MCPs) occurs. In Example 2 the switching-off of MCPs occurs only after switching-off of the turbogenerators i.e. through 191 seconds after the beginning of the accident. In the presence of it the reactor power at the moment of switching-off of the MCPs is equalled to 50 % of rated power. Nevertheless here and there the operation of emergency protection occurs after switching-off of the second turbogenerator. In our opinion the emergency sequence considered will not cause the conservative result. We think that it is necessary to consider in Example 2 the next accident sequence: false operation of four MSRVs occurs, at that very instant MCPs are at once disconnected. Further the Local Regulators work, which support constant reactor power, through some time the switching-off of turbogenerator 1 occurs, then turbogenerator 2 do and only after it the emergency protection occurs.

SINGLE FAILURE PRINCIPLE

Regulation documents require, that alongside with the Initiating Event a Single Failure in the Safety Systems was considered. It is naturally, that there is only one Initiating Event, but there are

many Single Failures. Therefore for the conservatism of the results received it is necessary to take only one, but a serious Single Failure. The authors of the production reports do not justify the choice of that or another Single Failure. For some unknown reasons almost for all the Initiating Events failure of the Check Valve on the Distribution Group Header is taken as the Single Failure. For some Initiating Events the calculations are carrying out without consideration of Single Failures.

FINDINGS

1. The developed nodalization schemes of the circulation circuit of the RBMK reactor are sufficient, initial data entered to RELAP code are correct, duration of the calculation time of failures is quite acceptable.
2. For the failures: breakage of Main Steam Lines and false operation and failure to close of MSRVs execution of additional calculations is necessary. Quantity of design-basis accidents analysed is not sufficient for reception of the licence for further operation of the power unit.
3. Internal examination of the production reports was conducted not very deeply.
4. The computational tool was prepared, which may be with small changes may be applied both for reception of the licence and for the Deterministic Support of the Probabilistic Safety Analysis